SCOS97-NARSTO
1997 SOUTHERN CALIFORNIA OZONE STUDY AND AEROSOL STUDY

VOLUME III: SUMMARY OF FIELD STUDY

FINAL REPORT
CONTRACT NO. 93-326

PREPARED BY:

ERIC M. FUJITA
MARK GREEN
ROBERT KEISLAR
DARKO KORACIN
HANS MOOSMULLER
JOHN WATSON

ENERGY & ENVIRONMENTAL ENGINEERING CENTER
DESERT RESEARCH INSTITUTE
P. O. BOX 60220
5625 FOX AVENUE
RENO, NV 89506

PREPARED FOR:

CALIFORNIA AIR RESOURCES BOARD
RESEARCH DIVISION
2020 L STREET
SACRAMENTO, CA 95814

FEBRUARY 1999

SCOS97-NARSTO
Volume III: Summary of Field Study

Prepared by:

Randy Pasek, Leon Dolislager, Ash Lashgari,
Nehzat Motallebi, Jim Pederson, and Tony Van Curen
Research Division
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

SCOS97-NARSTO
Technical Committee

Henry Hogo (Chair), South Coast Air Quality Management District
Don McNerny, California Air Resources Board
Bart Croes, California Air Resources Board

Working Groups

Meteorology
Joe Cassmassi (Chair), South Coast Air Quality Management District

Air Quality
Dennis Mikel (Chair), Ventura County Air Pollution Control District

Emission Inventory
Dale Shimp (Chair), California Air Resources Board

Quality Control Quality Assurance
Bart Croes, California Air Resources Board
Dennis Mikel, Ventura County Air Pollution Control District

For more information about the ARB's Research Division,
its research and activities, please visit our Web site:

http://www.arb.ca.gov/rd/rd.htm

Study Personnel and Supporting Organization (s)

Personnel	Activity	Affiliation	Funding
Ozone			
Planning			
Dr. Eric Fujita	Field & QA	Desert Research Inst	ARB ($110K)
Dr. Eric Fujita	QA Management	Desert Research Inst	Ventura CAPCD ($56K)
Emission Inventory			
Dr. Debbie Niemeier	Traffic Counts	UC Davis	ARB ($66K)
Mr. Roger Helvy	Shipping Traffic	U.S. Navy	U.S. Navy ($100K)
Dr. Debbie Niemeier	Truck Activity	UC Davis	NREL ($185K)
Tracer			
Dr. Russell N. Dietz	Tracer Release	Brookhaven National Lab	ARB ($30K) Pacific Merchant SA ($15K) Port of Long Beach ($50K) Port of Los Angeles ($25K) South Coast AQMD ($50K) Steamship Association ($25K) U.S. EPA ($100K) U.S. Navy ($100K)
Supplemental Measurements of Ozone, Total Oxides of Nitrogen, and Meteorological Parameters at Ground Level			
Mr. Dennis Fitz	NO_Y	UC Riverside CE-CERT	ARB ($240K)
Dr. Robert O'Brien	OH & O_2H	Portland State University	EPA ($220K)
Dr. Daniel Grosjean	PAN-PPN	DGA	ARB ($20K)
Mr. Jeffrey Shu	TDLAS	UC Riverside CE-CERT	ARB ($47K)
Dr. Ernesto Tuazon	FTIR	UC Riverside CE-CERT	ARB ($40K)
Dr. Janet Arey	Biogenics & PAH	UC Riverside	ARB ($51K)
Mr. Bob Ramirez	NOY	Mojave Desert AQMD	U.S.M.C. ($24K)
Mr. Dave Pankratz	Ozone & Met	Aerovironment	ARB ($173K)
Mr. Mark Podrez	Ozone & Met	RTP	San Diego CAPCD ($95K)
Radiation Measurements			
Mr. Dennis Fitz	Radiation Spectral, Broadband Continuous Aerosols	UC Riverside CE-CERT	ARB ($10K)
Dr. William Carter	Actinometer Licor Spectral Photolysis	UC Riverside CE-CERT	ARB ($9K)
Dr. James Gibson	UV Spectral	CSU-NREL	NREL (In-Kind)
Dr. John Rives	Brewers Spectral	University of Georgia	EPA (In-Kind)
Supplemental Speciated Hydrocarbon Measurements at Ground Level			
Mr. Dennis Fitz	VOC & Carbonyl	UC Riverside CE-CERT	ARB ($249K)
Dr. Barbara Zielinska	VOC & Carbonyl	Desert Research Inst	ARB ($156K) U.S. EPA ($50K)
Dr. Sucha Parmar	VOC & Carbonyl	Atmospheric Analysis	U.S. M.C. ($40K)
Dr. David A. Schorran	Halocarbons	Desert Research Inst	MDAQMD ($135K)

Ozone and Meteorological Measurements Aloft

Dr. C. Russell Philbrick	Ozone Lidar	Penn State University	ARB ($30K) MDAQMD ($30K) U.S. EPA ($25K) U.S. M.C. ($20K)
Dr. Yanzeng Zhao	Ozone Lidar	NOAA	ARB ($250K) U.S. EPA ($150K)
Dr. John Carroll	Cessna 182	UC Davis	ARB ($247K)
Mr. Alex Barnett	Met Audits	Aerovironment	ARB ($110K) San Diego CAPCD ($10K) South Coast AQMD ($25K)
Dr. Robert Weber	Met Data Mgmt	NOAA	ARB ($100K)
Dr. George Frederick	RWP-RASS (5)	Radian	ARB ($395K)
Dr. William D. Neff	RWP-RASS (11) Sodars (3)	NOAA	U.S. EPA ($850K)
Dr. Daniel Wolfe	RWP-RASS (2)	NOAA	U.S. EPA ($160K)
Mr. Jerry A. Anderson	Aztec	Sonoma Tech	ARB ($379K)
Mr. Dennis Fitz	Rawinsondes	UC Riverside CE-CERT	ARB ($40K)
Dr. Ken Underwood	Sodar(3), Rawin	Aerovironment	U.S.M.C. ($80K)
Mr. Roger Helvy	Rawinsondes	U.S. Navy	U.S. Navy ($25K)
Mr. Dennis Mikel	Rawinsondes	Ventura CAPCD	Ventura CAPCD ($44K)
Dr. Ken H. Underwood	Sodar	Aerovironment	San Diego CAPCD ($60K)
Mr. John Collins	Ozonesondes	UC Riverside CE-CERT	ARB ($536K)
Mr. Bill Brick	Rawinsondes	San Diego CAPCD	San Diego CAPCD ($25K)
Mr. William Gibbs	Cessna 182	Gibbs Flite Center	San Diego CAPCD ($82K)
Mr. William Gibbs	Navajo	Gibbs Flite Centere	San Diego CAPCD ($178K)
Mr. Roger Helvy	Partnavia Rawinsondes Ozonesondes Met Audits Surface Sites	U.S. Navy	U.S. Navy ($350K)
Mr. Dennis King	Met Audits	ARB	ARB (In-Kind)
Mr. Ken Stround	RWP-RASS (2)	ARB	ARB (In-Kind)
Mr. Kevin Durkee	RWP-RASS (2)	South Coast AQMD	South Coast AQMD (In-Kind)
Mr. Kent Field	RWP-RASS (1)	Ventura CAPCD	Ventura CAPCD (In-Kind)
Ms. Christy Crosiar	RWP-RASS (3)	U.S. Air Force	Vandenberg AFB (In-Kind)
Ms. Jean Timmerman	RWP-RASS (2) Sodar (1)	San Diego CAPCD	San Diego CAPCD (In-Kind)

Data Management & Analysis

Mr. Bill Brick	Analysis & Mgmt	San Diego CAPCD	San Diego CAPCD ($50K)
Dr. Paul Roberts	PAMS Analysis	Sonoma Tech	South Coast AQMD ($250K)

Aerosols

Supplemental Measurements at Ground Level

Mr. Dennis Fitz	Nitrate & Sulfate	UC Riverside CE-CERT	ARB ($3K)
Mr. Dennis Fitz	Ammonia	UC Riverside CE-CERT	ARB ($3K)
Dr. Kim Prather	Time of Flight MS	UC Riverside	ARB ($60K) NREL ($199K)
Dr. Glen Cass	Aerosol Comp	Cal Tech	CRC ($126K) NREL ($127K)
Dr. Susan Hering	Real Time Aerosol	Aerosol Dynamics Inc	CRC ($26K) NREL ($26K)
Dr. Susan Hering	Continuous Nitrate	Aerosol Dynamics Inc	EPRI ($70K)
Dr. Delbert J. Eatough	Organic/Elem Carb	Brigham Young Univ	EPRI ($90K)
Dr. Fred Rogers	Flow Audits	Desert Research Inst	EPRI ($20K)
Dr. Petros Koutrakis	Fed Ref Method	Harvard School of PH	EPRI ($100K)
Dr. Petros Koutrakis	Nephelometers	Harvard School of PH	NREL ($10K)

Measurements Aloft

Dr. John Seinfeld	CIRPAS	Cal Tech	ARB ($200K)

DISCLAIMER

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their sources, or their uses in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

TABLE OF CONTENTS

SECTION

List of Tables

List of Figures

1.0 INTRODUCTION AND BACKGROUND

This document provides a summary of field operations during the 1997 Southern California Ozone Study conducted in coordination with the North American Research Strategy for Tropospheric Ozone partnership (SCOS97-NARSTO). To assemble a synopsis of the field measurement program, policy and technical needs that brought stakeholders to participate in the SCOS97-NARSTO are recalled. Milestones for planning of, managing operations of, and analyzing data from SCOS97-NARSTO are provided to show how these needs have been translated and processed into the elements of the study. Field components are presented to briefly describe how the study elements operated and fit together. The SCOS97-NARSTO Technical Committee and working groups are noted for funding of aerometric field measurement program and for managing the study. An inventory of expected reports from SCOS97-NARSTO participants is also provided as a directory of resources for data analysis and for air quality simulation. It is anticipated that these analyses and simulations would produce data useful to developing better compliance strategy for attainment of ozone and aerosol standards in southern California.

To put the field operations summary into the proper context, the topography and the climatology of southern California is discussed in broad terms. To address ozone and aerosol formation and transport within this complex topography and meteorology, elements of operational intensive periods (IOP's) are defined. Forecasting and deployment decisions for each IOP are described. Summaries of overall observations for each episode day are detailed to characterize these IOP's. It is important to note that the forecasting and the field operations programs were successful in capturing data for the episodes most likely to meet the needs of regional air quality simulation.

Data analysts and air quality modelers would use field measurements to characterize and to simulate the atmospheric chemistry of southern California. Therefore, they have a critical need for detailed descriptions of field measurements during SCOS97-NARSTO. During SCOS97-NARSTO, contractors operated supplemental upper-air meteorological and air quality platforms and ground-level air quality and meteorological stations. Regional air quality districts operated existing surface air quality and meteorological stations and conducted additional measurements at these facilities. Parameters measured at each supplemental site are provided to describe spatial and temporal characteristics of southern California's atmospheric chemistry. Parameters measured at each existing site are available from the United States Environmental Protection Agency's Aerometric Information Retrieval System (AIRS) and appendices A and B Volume I of this document. A SCOS97-NARSTO Atlas with descriptions, photographs, and maps of supplemental study sites is provided on a CD-ROM upon request from the Research Division of the California Air Resources Board (ARB). All supplemental and many existing sites were successfully characterized during SCOS97-NARSTO.

1.1 Background and Issues

The 1990 Clean Air Act (CAA) amendments intended to overhaul the planning provisions for those areas not currently meeting the National Ambient Air Quality Standard (NAAQS). The NAAQS for ozone is exceeded when the daily maximum hourly average concentration exceeds 0.12 ppm more than once per year on average during a three-year period. The California State standard is more stringent: no hourly average ozone concentration is to exceed 0.09 ppm. The CAA identifies specific emission reduction goals, requires both a demonstration of reasonable further progress and attainment, and incorporates more stringent sanctions for failure to attain the ozone NAAQS or to meet interim milestones.

According to the 1990 CAA's classification structure for ozone nonattainment areas, the San Diego area is classified as serious, the Ventura and Southeast Desert areas are classified as severe, and the SoCAB is the only area in the country that is classified as extreme. Serious areas must attain the NAAQS by the end of 1999, severe areas by 2005 or 2007 (depending on their peak ozone concentrations), and extreme areas by 2010. The CAA prescribes minimum control measures for each ozone nonattainment area with more stringent controls required for greater degrees of nonattainment.

Emission reduction plans for ozone precursors in serious, severe, and extreme nonattainment areas are submitted to the U.S. EPA as a revision to the California State Implementation Plan (SIP). Each ozone plan contains a current emissions inventory, plans for enhanced monitoring of ozone and ozone precursors, and estimation of future ozone concentrations based on photochemical modeling. Each plan shows a 9 percent reduction in emissions of reactive organic gases (ROG) between 1996 and 1999, and 3 percent reductions per year thereafter, quantified at three year intervals to the attainment date.

The California Clean Air Act of 1988 requires the California Air Resources Board (ARB) to assess the relative contributions of upwind pollutants to violations of the state ozone standard in downwind areas. Previous studies in California have demonstrated pollutant transport between air basins on specific days, but these studies have not quantified the contribution of transported pollutants to ozone violations in downwind areas. Current air quality simulation approaches have several shortcomings in their representation of the physical and chemical processes involved in ozone formation due to the lack of field measurements to evaluate and refine their capabilities (NRC, 1991). In addition, the field measurements used for input to these models and to evaluate their validity do not adequately represent current emission rates, chemical composition, and air quality. The SCAQS was conducted over a decade ago and the South Central Coast Air Basin (SCCAB) has not been extensively studied since the South Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP) in 1984 and 1985. Since the SCAQS, there have been measurable changes in the air quality of the SoCAB based on analyses of the routinely available monitoring data (Fujita, 1992; Davidson, 1993). The SCOS97-NARSTO is intended to provide another milestone in the understanding of relationships between emissions, transport, and ozone standard exceedances, as well as to facilitate planning for further emission reductions needed to attain the NAAQS.

1.2 Study Goals and Technical Objectives

The goals of the study, recalled from Volume I of this document, are to :

1. Update and improve the existing aerometric and emission databases and model applications for representing urban-scale ozone episodes in southern California

2. Quantify the contributions of ozone generated from emissions in one southern California air basin to federal and state ozone standard exceedances in neighboring air basins. Apply modeling and data analysis methods to design regional ozone attainment strategies.

These goals are to be met through a process which includes analysis of existing data; execution of a large-scale field study to acquire a comprehensive database to support modeling and analysis; analysis of the data collected during the field study; and the development, evaluation, and application of an air quality simulation model for southern California.

Specific technical objectives of SCOS97 are as follows:

1. Obtain a documented data set of specified precision, accuracy, and validity that supports modeling and data analysis efforts.

2. Document the frequency, intensity, and character of high ozone concentrations and its VOC and NO_X precursors within and between neighboring southern California air basins, and determine how these have changed over the past decade.

3. Identify and describe transport pathways between neighboring air basins, and estimate the fluxes of ozone and precursors transported at ground level and aloft under meteorological conditions associated with high ozone concentrations.

4. Quantify the uncertainty of emissions rates, chemical compositions, locations, and timing of ozone precursors that are estimated by emission models.

5. Quantify the uncertainty of meteorological models in simulating transport and mixing of precursors and end-products within and between air basins.

6. Quantify the uncertainty of air quality models in simulating atmospheric transformation and deposition.

7. Provide the meteorological and air quality measurements needed to estimate, with stated uncertainty intervals, the contributions from background, regional mixing and transport, and local emitters to ozone concentrations that exceed standards in each of the air basins.

8. Provide the meteorological and air quality measurements needed to estimate the effects of different emission reduction strategies on ozone concentrations within and

beyond each air basin, and identify those that cause the greatest reduction in population exposure for the least cost.

1.3 Elements of SCOS97-NARSTO

To understand how elements of the study formed a cohesive structure, it is necessary to describe the SCOS97-NARSTO's chronology. The SCOS97-NARSTO Technical Committee (TC), formed early in this chronology, has planned, has directed, has funded, and has managed the study. Working Groups formed from the Technical Committee include the Meteorology, the Air Quality, and the Emission Inventory who, under the guidance of the TC, managed aspects of the study in their respective areas of interest and responsibility. The WGs have been instrumental in preparing and operating the SCOS97-NARSTO. A compressed and concise chronology is provided in Table 1.

In 1993, several air quality management districts in southern California proposed to sponsor the SCOS97 field study to address interbasin transport. In July 1994, the South Coast Air Quality Management District (SCAQMD) hosted an initial planning meeting. The meeting was attended by other districts (Mojave Desert, Santa Barbara County, San Diego, and Ventura County), EPA-Region IX, utilities (Pacific Gas & Electric and Southern California Gas Company), oil companies (Atlantic Richfield Company, Chevron, Texaco and Unocal), industrial research consortiums (Coordinating Research Council and Electric Power Research Institute), and representatives of academia. The TC and WGs were formed to define goals and technical objectives for the proposed study and to provide coordination among sponsoring organizations. Memberships of the working groups are listed in Appendix C of Volume I of this document. A conceptual plan was completed by WGs and approved by the TC in November, 1995. This conceptual plan proposed the study goals and deliverables, the technical objectives, measurement requirements, data analysis activities, and modeling approaches. It is important to note that the planning process began at least two years before the field program, and there was at least one year time to incorporate of the results of pilot studies into the full program plan.

The SCOS97 conceptual plan (ARB, 1995a) provided the basis for the June 1996 draft of the field study plan (Fujita et al., 1996). The draft field study plan matched the SCOS97 goals and objectives with the resources available to do the job, and specified the details of the field study plan that would allow the conceptual plan to be executed. This version of the field study and quality assurance plan reflects the final stages of the planning process for the SCOS97-NARSTO Field Study. The overall design process was iterative and the final plan incorporated input from sponsors, other stakeholders, knowledgeable peer reviewers, and users of the data.

1.0 In further preparation for SCOS97-NARSTO, sponsors executed pilot studies such as the Barstow Halocarbon Study by the Desert Research Institute (DRI). This study in 1994, 1995, and 1996 investigated patterns of air pollution transport between the South Coast air basin and the Mojave and the Saltan Sea air basins. The 1995 Air Pollution Transport Corridors study further investigated the three dimensional nature of this inter-basin transport by employing additional supplemental ozone and meteorological sites and by using an instrumented

airplane and a scanning ozone light detection and ranging (lidar) instrument. This study marked the first deployment of a scanning ozone lidar in California. Both these pilot studies contributed to our knowledge of the most important sites and times to characterize and to monitor these interbasin air pollution transport couples and the siting of many SCOS97-NARSTO supplemental ozone sites. The Upper-Air Ozone Measurement Intercomparison Study at Walnut Grove and at Sandia National Laboratory allowed comparison of data from and evaluation of an ozonesonde, an instrumented aircraft, and an ozone lidar (Sandia) that was originally designed for monitoring atmospheric water content. A scanning ozone lidar, a lidar operating in generally the same manner as the Sandia lidar [operated for only two weeks], ozonesondes, and instrumented airplanes provided the primary air quality data aloft during SCOS97-NARSTO intensive operational periods.

In a preliminary effort, the emission inventory WG reviewed and corrected a Systems Application International (SAI) produced 1990 base emission inventory sponsored by ARB. This base inventory would then be used to develop a gridded 1996 base emission inventory which would then be grown into a 1997 gridded emission inventory. This emission inventory system would then be ready to integrate the day specific emission inventory data collected during SCOS97-NARSTO. To investigate ship borne emissions, the United States Navy planned and executed a pilot study on ship traffic into and out of the southern California bight. Members of the emission inventory WG have asked major sources in their domains for day-specific information and nearly sixty percent have already provided such data. Under contract to ARB, University of California Davis collected light-duty vehicle and heavy-duty truck traffic counts as inputs for traffic models. Depending on the release of growth factors and other related information from the Southern California Association of Governments, it is estimated that the emission inventory process would meet the air quality modeling chronology.

All three WGs put significant emphasis in selecting their QA programs and the TC selected the DRI as the overall SCOS97-NARSTO QA manager. The speciated hydrocarbon and carbonyl sampling QA relied on round-robin interlaboratory and intermethod comparisons. Whenever possible different measurement methods were collocated to permit comparisons for estimating accuracy and validity of the data. These measurements included ozone from lidar and from instrumented airplanes, PAN, NO_y, aerosols, radiation, and upper air meteorology. The meteorology WG planned and executed an extensive program of system and performance audits for upper air meteorology, which will be discussed in detail later. For nitric acid, the tunable diode laser spectroscopic was used as a "reference" method. Data archival has been emphasized as an integral part of the overall study and will be sited at ARB Technical Support Division. Data reporting conventions, site documentation, and units have been established and communicated to the study participants. Extensive data management and "Level 2" data validation for the upper-air meteorology, air quality aloft, speciated hydrocarbon and carbonyl, and NOY data has been planned.

On May 15, 1997, SCAQMD hosted the Measurement Coordination Meeting where intensive operational period (IOP) protocols and data exchange agreements were

discussed and approved. Program management and quality assurance issues were resolved at this meeting. The SCOS97-NARSTO field operations program began on June 16 and ended on October 15, 1997. Due to the El Niño driven climatology and the introduction of federal and California reformulated gasolines, the conditions for formation of high ozone episodes were less robust than during the 1993 Los Angeles Free Radical Study. Nevertheless, high ozone conditions were observed on July 3 [a non-IOP day due to unusual emission patterns], August 4 to 7, 22 to 23, September 3 to 6, 22 to 23, and 27 to 29, 1997. More detailed description of the IOP days are provided in the section 2.5 of this document.

To prepare for the upcoming State Implementation Plan 2000 for ozone and aerosols, early emphasis will be on airshed modeling of the SCOS97-NARSTO data. SCAQMD has sponsored Sonoma Technology, Inc (STI) to provide guidance, inputs, and data for evaluation of emissions, meteorological, and photochemical models, as part of the air quality management plan process. This project will also validate the SCOS97-NARSTO speciated hydrocarbon and carbonyl data and determine the air quality and meteorological representativeness of the SCOS97 episodes. ARB Research Division would conduct more observation-based analyses of upper-air quality and the NO_Y data. This group would also conduct observation-based and receptor modeling analyses on the data from the Aerosol Study during SCOS97-NARSTO. The summary and preliminary analyses of the SCOS97-NARSTO results will be presented at the 1998 Air and Waste Management Association's 91st Annual Meeting in San Diego, California. A Data Management and Analysis Plan will be prepared and presented to the TC in August of 1998. The University of California Los Angeles will host the SCOS97-NARSTO Data Analysis Symposium in June of 1999. Selected papers from this symposium will be combined in the SCOS97-NARSTO issue of Environmental Science and Technology. The SCOS97-NARSTO data will likely provide the basis for air quality scientific inquiry and air pollution policy in southern California for the next decade.

The SCOS97-NARSTO benefited from a communication system that heavily relied on the world wide web for disseminating IOP decisions, meteorological and air quality forecasts, and during the study even provided upper-air meteorological profiles from selected sites in a timely manner. Traffic count updates and other real-time resources describing conditions in southern California were also available to study participants through the world wide web. A list of selected SCOS97-NARSTO related sites is provided in Table 2 of this document. These sites provide information, reports, and data connected with the SCOS97-NARSTO. For information on SCOS97-NARSTO level II data's future release times and exchange protocol, it is recommended that the ARB Research Division site be monitored.

1.4 Components of the SCOS97-NARSTO Field Study

Since Dr. Haagen Smit explained the basic nature of photochemical smog in 1952, research in the laboratory and the real world has focused on better understanding the nuances of the complex photochemical processes that occur in our atmosphere. But, routine monitoring for many of the "exotic participants" in the photochemical reactions such as peroxy acetyl, proxy propionyl, and other organic nitrates is outside our technical and/or financial resources. Other "exotic participants" such as isoprene, and other

biogenic emissions, and product of their atmospheric oxidation by free radicals, until recently, had not been measured in real-time. Even basic building blocks of atmospheric chemistry of ozone and aerosols such as nitrogen dioxide, hydroxyl radical, nitric acid, and ammonia are extremely difficult to measure directly and in real time with sufficient sensitivity, accuracy, and precision. Major field studies are occasionally conducted with components specifically designed to measure these "exotic participants" so that we may learn the details of the atmospheric processes and how we may need to change emissions in the future to attain healthful air for the residents of California.

Ironically, many of these field studies (which take years to plan) unintentionally occurred during years when air pollution levels were lower than normal. No matter the meteorological conditions, the process of improving air quality relies on conducting field studies and incorporation the results into the planning process for controlling emissions. The SCOS97-NARSTO was also "plagued" by good meteorology when the smog season of 1997 (the cleanest season on record) produced only one Stage One ozone episode (1-hour concentration 20 pphm)--in contrast to seven, 14, 23, 24, and 41 during the prior five years. The good dispersion of pollutants during this study (which included the effects from three hurricanes in the study area) is generally credited to the well-publicized El Niño.

The field study portion of SCOS97-NARSTO was designed to maximize the chances of capturing high ozone episodes and to fill in the "holes" in our knowledge uncovered by previous studies.

Five types of ozone episodes in southern California were of interest. The study was successful in capturing all of the episode types except one (Type 5--Offshore Transport to San Diego). This last episode type was partially captured because it did occur two weeks after the study officially ended while certain SCOS97-NARSTO monitoring resources were still operational.

Remote sensing methods were employed to continuously monitor meteorological conditions aloft throughout the study period of June 16 through October 15. Previous studies provided only limited characterization of meteorological conditions aloft (with balloons and aircraft deployed during periods forecast to have high ozone concentrations) and this severely hampered the analyses of data in this area of complex meteorology and topography. In SCOS97-NARSTO, a network of 35 remote sensing systems was established (the densest network of radar wind profilers and sodars ever assembled) to continuously monitor wind and temperature conditions aloft throughout and around the South Coast Air Basin. During periods when high ozone concentrations were forecast, additional measurements on conditions aloft were obtained by means of ozonesonde releases at seven sites, rawinsonde releases at thirteen sites, six aircraft, and two lidars; in all, over 1,000 balloons were released during the study. At over 20 surface monitoring sites and on three aircraft, volatile organic compounds were sampled. These additional measurements provide critical detailed information pertinent to running and validating air quality models.

Because previous modeling efforts underestimated the amount of ozone in the central basin where ozone concentrations tend to be highest, the El Monte Airport, near the center of the basin, was established as the hub site for enhanced monitoring. An ozone lidar and a radar wind profiling system (RWP) were operated nearly continuously during the intensive periods to identify the dynamics of ozone and meteorological conditions with height and time. These data were supplemented by measurements of ozone, oxides of nitrogen, temperature, humidity, and particles on up to nine aircraft spirals during daylight hours.

Previous studies demonstrated the complexity of air circulation over the southern California bight and how important it is to adequately characterize the offshore meteorological conditions and air quality. Air quality and meteorological monitoring offshore were greatly enhanced for the SCOS97-NARSTO which included sites on San Clemente, San Nicolas, Santa Catalina, and Santa Rosa Islands as well as at eight new coastal locations; measurements of conditions aloft were taken at eight of the dozen sites. During intensive operational periods, an instrumented aircraft (making morning and afternoon flights) provided additional, detailed data on conditions in the southern California bight during over-water sampling in an elliptical path encompassing the islands. On occasion, a second aircraft mapped the distribution of ozone concentrations inside the northeast quarter of the ellipse by sampling over the ocean west and southwest of Santa Monica Bay.

An important objective of SCOS97-NARSTO was to understand why ozone levels are improving at a slower rate on weekends than weekdays, the so-called "weekend effect." For the first time, detailed information (over 300 megabytes of data a day) was collected on the operations of cars, trucks, airplanes, ships, and major point sources every day for four months. This data will be analyzed to determine the differences in pollutant emissions on weekdays and weekends. Also, day-specific biogenic hydrocarbon emissions inventories are being assembled for comparison with the anthropogenic emissions.

An aerosol component of the study collected detailed data on the size distribution of particles at ground level and aloft. Real time measurements were also made of particles at some ground level sites. Size and composition information on over two million individual particles were collected during at least ten different types of fine particle episodes. Despite a shoestring budget, a wide variety of simple and sophisticated solar radiation instruments were brought to the study for evaluation of the sensitivity of ozone formation to both the radiation absorbing and scattering properties of particles. During another component of the study, releases of up to five different tracers were made to simulate emissions from shipping channels. This information will be used to compare how ship emissions from the current and proposed shipping lanes might impact air quality when they come on-shore.

Despite the cleanest air quality on record for the study area, the team of forecasters successfully predicted the days with the second and third highest concentrations (the day with the highest concentration of the year was not of interest because it occurred on July 3

after several days of forest fires and when traffic patterns were likely atypical due to the holiday weekend).

Although the monitoring phase of SCOS97-NARSTO is over, much work remains as the study participants attempt to fully utilize the data collected and address the informational needs of the study sponsors. This study will provide the first detailed analyses of the causes contributing to violations of the new national 8-hour ozone and 24-hour PM2.5 standards. The data collected will be used in modeling and data analyses that will provide the most definitive answers yet to solving the persistent air quality problems in a complex region. The cooperation of the study sponsors (U.S. EPA, local air pollution control districts, U.S. Marine Corps, U.S. Navy, National Renewable Energy Laboratory, Coordinating Research Council, EPRI, Southern California Edison, and ARB) in integrating and "piggybacking" projects made it possible to leverage the available funds for maximum scientific benefit.

1.5 Sponsors and Management

SCOS97-NARSTO has been a large undertaking involving many contractors, sponsoring organizations and governmental agencies. In a cooperative study such as this, no one person can have direct management authority over all phases of the study. Since direct fiscal responsibility will remain with the California Air Resources Board (ARB), South Coast Air Quality Management District (SCAQMD), San Diego Air Pollution Control District (SDAPCD), Ventura County Air Pollution Control District (VCAPCD), Mojave Desert Air Quality Management District (MDAQMD), United States Navy, Coordinating Research Council (CRC), the management structure for SCOS97-NARSTO reflects this consortium of sponsors. The setting for the development and progress of this consortium has been the SCOS97-NARSTO Technical Committee. A list of study personnel and supporting organizations is provided in the preamble to this volume. Lists of in-kind support are provided in specific measurement categories in the Volume I of this document.

The Technical Committee (TC) has set the goals of the study and has made decisions regarding general study objectives, funding, and selection of contractors. The TC is made up of technical staff members from ARB (Research and Technical Support Divisions), SCAQMD, SDAPCD, VCAPCD, Santa Barbara APCD, MDAQMD, EPA-Region IX, United States Marines, and United States Navy. The TC has directed the planning efforts and has coordinated the technical activities of the contractors to ensure that the measurement, emission, modeling, and analysis activities are coordinated with each other and focused on the study objectives. A list of the TC members is provided in Appendix C of Volume I, The Operational Program Plan, of this document.

The Meteorology Working Group was primarily responsible for the largest and the most dense network of upper-air meteorological measurements ever assembled in southern California. This network included 28 Radar Wind Profiler and Radio Acoustic Sounding Systems (RWP-RASS), 7 Sound Detection and Ranging Systems (sodars), rawinsonde launches from 13 launch sites, and meteorological data associated with ozonesondes from 7 launch sites. The rawinsonde launches were restricted to 4 times daily during intensive operational periods. The MWG was also primarily responsible for the success of system

and performance audits conducted during the study to assure the highest quality meteorological data was collected during SCOS97-NARSTO. MWG leaders have come from ARB (Bruce Jackson – co-chair and Steve Gouze), from SCAQMD (Joe Cassmassi – co-Chair and Kevin Durkee), from SDAPCD (Bill Brick and Virginia Bigler-Engler), from VCAPCD (Kent Field), and from U.S. Navy (Roger Helvy and Jay Rosenthal).

The Air Quality Working Group is primarily responsible for developing, operating, and managing the first total reactive nitrogen species (NO_Y) network in southern California and the ozone sites supplemental to the Routine Network. Supplemental ozone sites are sites operated specially for SCOS97-NARSTO or are sites whose data have not been routinely submitted to AIRS. State and Local and National Air Monitoring Stations (SLAMS and NAMS) data are routinely submitted to AIRS. This, Routine Network, collects aerometric data including ambient concentrations of gases such as ozone, oxides of nitrogen, sulfur dioxide, carbon monoxide, methane, and ambient meteorological parameters such as temperature, relative humidity, wind parameters, pressure, radiation, and aerosols data such as particulate matter less than 10 micron in aerodynamic size (PM10). During 1998 and later, many sites in this Routine Network will also collect PM less than 2.5 micron in aerodynamic size (PM2.5 or PM Fine) data. The quality of the data and what parameters are collected vary considerably from site to site. This is primarily due to regional district's resources and their ozone and aerosol attainment demonstration status. It is important to understand that to a certain extent the NO_Y, the speciated hydrocarbon and carbonyl (VOC), and the aerosol networks were essentially superimposed on existing Routine Network. The Routine Meteorological Network includes the aerometric stations, as well as those stations operated by the National Weather Service, National Park Service, and fire safety and prevention concerns. Types of SCOS97-NARSTO sites are discussed in detail in section 3.1 of this volume.

The VOC network improved the spatial and temporal extent and data quality assurance of the Photochemical Assessment Monitoring Stations (PAMS) at 20 stations in the SCOS97-NARSTO domain. The NO_Y network operated at 14 sites, five were new sites where ozone and meteorological parameters were also measured. There were 31 supplemental ozone sites during SCOS97-NARSTO. It is important to note that there were supplemental stations that collected ozone, aerosol, and NO_Y data simultaneously. It is also important to note that some supplemental stations, those in the Children's Health Study Network, are operated year-around and on a semi-permanent basis.

The study's Field Program Management Committee (FPMC) provided the day-to-day technical management during the field study. The FPMC made decisions regarding intensive operation periods, and contingency funding. This committee included a single representative from the ARB Research Division (Bart Croes), ARB Research Division (Don McNerny), SCAQMD (Henry Hogo), SDAPCD (Judy Lake - Chair), VCAPCD (Doug Tubbs), U.S. EPA (Carol Bohnenkamp), U.S. Navy (Jay Rosenthal).

The forecast team developed the Forecast Plan in conjunction with the field manager, reviewed meteorological data, and provided consensus forecasts to the FPMC. The forecast team also documented the daily meteorological conditions during 1997. This

team included a single representative from the ARB (Steve Gouze), SCAQMD (Joe Cassmassi – Chair), SDAPCD (Virginia Bigler-Engler), VCAPCD (Kent Field), and U.S. Navy (Jay Rosenthal).

The Field Managers coordinated the activities of the field contractors (in-kind personnel will be under the direction of their management/FPMC members). Jim Pederson (upper-air meteorology), Leon Dolislager (air quality), Dr. Ash Lashgari (surface meteorology, ozone and NOy) and Dr. Randy Pasek (VOC) of the Air Resources Board Research Division were the FMs and the main contact points to relay information on measurement readiness status during and between the intensive operational periods (IOPs). Mr. Bart Croes of the Research Division coordinated their activities and provided day-to-day communication and leadership support.

The Quality Assurance manager has been responsible for developing the QA plan in conjunction with the field managers and field contractors. The QA manager supervised the systems and performance audits and reported their results to the field manager and field contractors. The QA manager has worked with the data manager to develop quality assurance data screening protocols and has managed the data quality assurance efforts. Dr. Eric Fujita of the Desert Research Institute has been the QA manager and has reported to the SCOS97 Technical Committee.

The Data Manager is responsible for developing the data management plan in conjunction with the field managers and field contractors. The data manager works with the field manager, measurement contractors, modelers, and analysts to develop standard data formats for use in the study. The data manager is responsible for obtaining project data and supplemental data, integrating the data into a common database, performing Level 1 screening of the data, providing the data to the QA, analysis, and modeling contractors, and documenting and maintaining the data archive. Mrs. Liz Niccum of the Air Resources Board Technical Support Division has been designated the data manager.

The data management process is the beginning of the analysis and modeling of SCOS97-NARSTO data set. This process would soon lead to the availability of this massive data set to the community of atmospheric scientists.

1.6 Guide to Study Reports

To better understand this data set and to be able to focus the scientific inquiry into diverse aspects of the SCOS97-NARSTO, it is important to note what reports are, and would be, available to guide any search for relevant data. Volume I and III of this document are particularly useful for planning of future studies such as the San Joaquin Valley Study 2000 or other studies with limited focus on aerosols, on nitrogen species measurements, and on radiation issues. Volume II reflects the SCOS97-NARSTO QA approach, which would be useful to understand the outlines of the QA program in each particular area and SCOS97-NARSTO innovations on how specific QA programs would be designed. This volume, IV, serves to high light particulars of SCOS97-NARSTO field operations; this volume is useful to focus on particular IOP's and the measurements of particular relevance

during each IOP of interest. Volume V documents actual QA practices to guide the selection of what information are abstracted from the data set.

Other upcoming reports from contractors who participated in the SCOS97-NARSTO field program are listed in Table 3. It is important to note that this list would likely be updated and made part of the SCOS97-NARSTO ARB Research Division internet site.

Table 1
SCOS97-NARSTO CHRONOLOGY

Date	Milestone
September 1993	RSC meeting - Present planning RFP
December 1993	RFP released
February 1994	Responses received
March 1994	RSC Meeting - Planning RFP awarded to DRI
July 1994	Concept Meeting at South Coast AQMD - Formation of TC
January 1995	Feasibility study for a southern California Air Quality Monitoring Study. Report prepared by SAI for CRC
May-October 1995	Pilot studies - Barstow Halocarbon Study, ozone aloft monitoring, and scanning lidar evaluations
November 1995	Conceptual Plan for SCOS97-NARSTO prepared by the TC and WGs
June 1996	Draft SCOS97 Field Study Plan prepared by DRI with input from TC and WGs
August 1996	Preliminary regional meteorological modeling
October 1996	SCOS97 sponsors release RFPs
December 1996 -March 1997	Contracts in place
April 1997	Draft SCOS97-NARSTO Quality Assurance Plan prepared by DRI with input from TC, WGs, and measurement contractors
May 1997	Measurement Coordination Meeting
June 1997	Final SCOS97-NARSTO Field Study and Quality Assurance Plan prepared by DRI with input from TC, WGS, and measurement contractors
June 16, 1997 to October 15, 1997	Conduct SCOS97-NARSTO field study
May 1998	RSC Meeting – Present Operational Plan, Quality Assurance Plan, Aerosol Study Field Plan, Summary of Field Operations, Summary of Quality Assurance
June 1998	Complete assembly and validation of data archive
June 1998	SCOS97-NARSTO symposium I – AWMA 91st Annual Meeting – Review of field study and preliminary interpretation of data
August 1998	TC Meeting – Present Data Management and Analysis Plan
March 1999	Complete data analysis
June 1999	Regional meteorological modeling evaluation and emission inventory due for the SIP process
June 1999	SCOS97-NARSTO symposium II – ES&T Special Issue – Data Analysis
January 2000	Regional air quality model evaluation due for the SIP process
June 2000	Regional control strategy assessment due for the SIP process

Table 2
SCOS97-NARSTO WORLD WIDE WEB SITES

Source	Address
ARB	http://arbis.arb.ca.gov/homepage.htm
ARB	http://www.arb.ca.gov/scos/scos.htm
ARB Monitoring Sites	http://arbis.arb.ca.gov/aqd/ozone/lst1_ste.htm
NOAA	http://www7.etl.noaa.gov/programs/SCOS97/
NOAA	http://www4.etl.noaa.gov/index.html
DRI	http://www.dri.edu/EEEC/Faculty/Fujita.html
CE-CERT	http://cert.ucr.edu/~macm/
CE-CERT	http://www.cert.ucr.edu/ap/air.html
U.S. Navy	http://www.enviro.navy.mil/
U.S. Navy	http://web.nps.navy.mil/~cirpas/past_proj.html
Santa Barbara CAPCD	http://www.silcom.com/~apcd/ota/mayjun97.htm
South Coast AQMD	http://www.aqmd.gov/scos97/
South Coast AQMD	http://www.aqmd.gov/news/smog97_1.html
UCLA	http://www.ph.ucla.edu/ese/w_rsrch.htm
EPA	http://www.epa.gov/region09/air/
EPA	http://www.epa.gov/region09/air/sip/casip3.html
Mojave Desert AQMD	http://www.mdaqmd.ca.gov/
San Diego CAPCD	http://www.sdapcd.co.san-diego.ca.us/scos97.html
U.S. Dept of Energy	http://www.doe.gov/
CRC	http://crcao.com/
Cal Trans	http://www.scubed.com/caltrans/

Cal GAP Project	http://www.biogeog.ucsb.edu/projects/projects.html
NARSTO	http://odysseus.owt.com/Narsto/1998NewsletterWS.pdf
PSU	http://horizons.sb2.pdx.edu/~fage/
CIMIS	http://wwwdpla.water.ca.gov/cimis/cimis/hq/
NWS	http://nimbo.wrh.noaa.gov/wrhq/profile.html
NPS	http://www.aqd.nps.gov/ard/
NPS ARD	http://www.aqd.nps.gov/ard1/
NPS IMPROVE	http://www.aqd.nps.gov/ard1/investhp.html

Table 3
GUIDE TO STUDY REPORTS

Contractor	Number	Expected Date	Sponsor	Title
SJSU- Bob Bornstein Penn State- Nelson Seaman	97-310	July 2000	ARB-RD	*Improvement and Evaluation of the Mesoscale Meteorological Model MM5 for Air Quality Applications in Southern California and the San Joaquin Valley*
UC Berkeley- Rob Harley	96-335	December 99	ARB-RD	*Review and Improvement of Methods for Estimating Rates of Photolysis in Photochemical Models*
UC Riverside- CE-CERT-Dennis Fitz	96-504	September 98	ARB-RD	*Measurement of Nitrogenous Species & Solar Intensity During SCOS97*
NOAA-Yanzeng Zhao	95-337	December 98	ARB-RD	*Measurement of Ozone Concentrations Aloft During the Episodic Monitoring Periods of the SCOS97*
STI-Don Blumenthal	96-309	November 98	ARB-RD	*Investigation of Processes Leading to the Formation of High Ozone Concentrations Aloft in Southern California*
UCD- John Carroll	95-332	September 98	ARB-RD	*Aircraft Measurements in Support of SCOS97*
U.S. Navy, Naval Facilities Engineering Service Center-Norm Helgeson	97-304	October 98	ARB-RD	*Measurements of Ozone and Meteorological Conditions in the Low Atmosphere During SCOS97*
California Institute of Technology-John Seinfeld	96-315	February 99	ARB-RD	*Aircraft Sampling to Determine Atmospheric Concentrations & Size Distributions of PM & Other Pollutants over the SoCAB*
UC Riverside - CE – CERT-Dennis Fitz	96-322	November 98	ARB-RD	*Surface and Upper-Air VOC Sampling and Analysis During SCOS97*
NoAA-Bob Weber	96-323	October 98	ARB-RD	*Management of Data from the Upper-Air Meteorological Network for SCOS97*
AeroVironment- Bob Baxter	96-320	August 98	ARB-RD	*Audit of Radar Wind Profiler Network and Selected Surface Meteorological Sites for the SCOS97*
AeroVironment- Bob Baxter	96-320	August 98	ARB-RD	*Addendum to the final QA report, soundings made by the ARB and the U. S. Navy for QA purposes at 12 radar wind profiler sites will be compared with radar wind profiler soundings*
NOAA-William Neff	95-345	March 99	ARB-RD	*Enhancement of the Existing Radar Wind Profiler Network for SCOS97*
UCLA- Arthur Winer-Proposal	2354-202	June 2000	ARB-RD	*Development and Validation of Databases for Modeling Biogenic Hydrocarbon Emissions in California's Airsheds*
UCLA- Arthur Winer	95-309	September 98	ARB-RD	*Biogenic Hydrocarbon Inventories for California: Generation of Essential*

				Databases
Radian/STI- George Frederick	96-318	May 99	ARB-RD	*Enhancement of the Existing Radar Wind Profiler Network for SCOS97*
SAI-Julie Fieber	974-734	March 97	ARB-TSD	*Preparation of a Draft 1990 Gridded Emission Inventory for Southern California*
RFP	97-715	June 2000	ARB-TSD	*Develop SCOS-97 NARSTO Gridded Emission Inventories*
AeroVironment- David Pankratz	96-719	September 98	ARB-TSD	*Supplemental Monitoring for Recirculation Patterns in the SoCAB*
UC Riverside - CE – CERT- Dennis Fitz	95-723	September 98	ARB-TSD	*Performing Ozonesonde Measurements for the SCOS97*
STI-Paul Roberts	-	July 99	SCAQMD	*PAMS and SCOS97 Data Analysis Project*